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U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER
NIP-275

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)

U.S. APPLICATION NO (if known, see 37 CFR 1.5)
10/088114

International Application No	International Filing Date	Priority Date Claimed
PCT/JP99/05779	October 20, 1999	

Title of Invention GAS TURBINE COMBUSTOR, PRE-MIXER FOR TURBINE COMBUSTORS AND PREMIXING METHOD FOR GAS TURBINE COMBUSTORS

Applicant(s) for DO/EO/US H. INOUE et al (see attached)

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   - a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau).
   - b. [X] has been transmitted by the International Bureau.
   - c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [X] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   - b. [ ] have been transmitted by the International Bureau.
   - c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   - d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [X] Other items or information:

[X] LIST OF INVENTORS' NAMES AND ADDRESSES.

[X] THIS APPLICATION IS BEING FILED WITHOUT AN EXECUTED DECLARATION, WHICH WILL BE FILED LATER.

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U.S. Application No (if known, see 37 CFR 1 5)	International Application No	Attorney's Docket Number
10/088114	PCT/JP99/05779	NIP-275

	CALCULATIONS	PTO USE ONLY
17. [X] The following fees are submitted: Basic National Fee (37 CFR 1 492 (a)(1)-(5)). Search Report has been prepared by the EPO or JPO .... $890.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) .... $710.00 No international preliminary examination fee (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445 (A)(2)) .... $740.00 Neither international examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(A)(2)) paid to USPTO .... $1040.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2) to (4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [X] 30 months from the earliest claimed priority date (37 CFR 1.492(e)). +	$ 130.00	

Claims	Number Filed		Number Extra	Rate		
Total	17	-20 =	0	x $18.00	$ 0.00	
Independent	14	- 3 =	11	x $84.00	$ 924.00	
Multiple dependent claim(s) (if applicable)				+ $280.00	$ 0.00	

	CALCULATIONS	PTO USE ONLY
TOTAL OF ABOVE CALCULATIONS =	$ 1,944.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).	$ 0.00	
SUBTOTAL =	$ 1,944.00	
Processing fee of $130.00 for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +	$ 0.00	
TOTAL NATIONAL FEE =	$ 1,944.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property. +	$ 0.00	
TOTAL FEES ENCLOSED =	$ 1,944.00	
	Amount to be: Refunded	$
	Charged	$

a. [X] **A check in the amount of $ 1,944.00 to cover the above fees is enclosed.**

b. [ ] **Please charge my Deposit Account No. 50-1417 in the amount of $ ________ to cover the above fees. A duplicate copy of this sheet is enclosed.**

c. [X] **The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-1417. A duplicate copy of this sheet is enclosed.**

Note: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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NIP-275

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

H. INOUE et al

Serial No.

Filed: March 15, 2002

For: GAS TURBINE COMBUSTOR, PRE-MIXER FOR TURBINE COMBUSTORS AND PREMIXING METHOD FOR GAS TURBINE COMBUSTORS

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to the examination thereof, please amend the above-identified application as follows.

IN THE CLAIMS

Please rewrite claims 4 and 5 as set forth below.

4. (Amended) A gas turbine combustor according to claim 1, characterized in that each of the opening portions is provided between the adjacent two premixing nozzles at the position in circumferential direction.

5. (Amended) A gas turbine combustor according to claim 1, characterized in that each of the opening portions is configured in such a manner that the opening width in circumferential direction varies along the axial direction thereof.

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REMARKS

Examination is respectfully requested.

Respectfully submitted,

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Date: March 15, 2002

MARKED UP VERSION OF REWRITTEN CLAIMS

4. (Amended) A gas turbine combustor according to claim 1 [or 2], characterized in that each of the opening portions is provided between the adjacent two premixing nozzles at the position in circumferential direction.

5. (Amended) A gas turbine combustor according to claim 1 [or 2], characterized in that each of the opening portions is configured in such a manner that the opening width in circumferential direction varies along the axial direction thereof.

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Title of the Invention

GAS TURBINE COMBUSTOR, PRE-MIXER FOR TURBINE COMBUSTORS AND PREMIXING METHOD FOR GAS TURBINE COMBUSTORS

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SPECIFICATION

Gas Turbine Combustor, Pre-Mixer for Turbine Combustors and Premixing Method for Gas Turbine Combustors

FIELD OF THE INVENTION

The present invention relates to a premixer for gas turbine combustors, a premixing method for gas turbine combustors, a gas turbine combustor and a combustion method for gas turbine.

BACKGROUND ART

In a gas turbine combustor and a combustion method for gas turbines, in order to reduce exhaust amount of NOx which is an air pollution material, an application of premixing combustion method is now progressing in which fuel and air premixed before the fuel is introduced into a combustion chamber. For example, as disclosed in JP-A-3-175211 (1991), a diffusive combustion showing excellent stability is assigned at the center portion of the combustion chamber and a premixing combustion showing excellent low NOx property is assigned at the outer circumferential side thereof, thereby, NOx reduction is achieved. In this disclosure, air sent from a compressor passes between a combustor outer cylinder and a combustor liner and flows in respectively such

as a combustion chamber and a pre-mixer.

Diffusive combustion use fuel is injected from a diffusion fuel nozzle into the combustion chamber to form stable diffusive flame and premixing use fuel is injected from a premixing fuel nozzle into an annular premixer to mix air and to from premixed gas.

The above premixed gas flows out into the combustion chamber to form premixing flame. The generated high temperature combustion gas is introduced into a turbine to perform works and thereafter is exhausted.

In a low NOx combustor making use of such premixing combustion, formation of uniform premixed gas greatly affects the low NOx performance. In particular, in the above conventional example which is structured in such a manner that the air flow makes a U turn at the inlet of the premixer, a drift with regard to air flow is likely caused which makes difficult to form a uniform mixing gas. Namely, for such measure it requires great attention of advancing the mixing in the premixer.

With regard to air flow in such premixer, JP-A-60-223578 (1985) and JP-A-2-267419 (1990), for example, disclose technical measures therefor.

JP-A-2-267419 (1990) discloses such a technique that a partition wall is provided for every nozzles so as to separate the same in the circumferential

direction in the premixer, inlet windows of which opening is deviated are provided so that premixing combustion use air flows in an deviated manner, thereby a swirl component is caused in the premixing combustion use air and the mixing with fuel is advanced. However, the disclosure does not fully takes into account the relationship between the window configuration and the fuel nozzles.

An object of the present invention is to provide a premixer for gas turbine combustor, a premixing method for gas turbine combustors, a gas turbine combustor and a combustion method for gas turbines which uniformalize the premixing and show an excellent low NOx performance.

A gas turbine combustor according to the present invention comprising diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which from an annular premixing flow passage and premixing nozzles which are disposed in the premixing flow passage and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, is characterized in that a plurality of the premixing nozzles are arranged in the premixing flow passage; opening portions permitting air to flow in are provided at the outer wall so that the air flowed into the premixing flow

passage forms swirling flow with respect to the premixing nozzles; and the opening portions are disposed in circumferential direction and are provided one for every adjacent two premixing nozzles.

A gas turbine combustor according to another aspect of the present invention comprising diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular premixing flow passage and a premixing nozzles which are disposed in the premixing flow passage and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, is characterized in that a plurality of the premixing nozzles are arranged in the premixing flow passage; opening portions permitting air to flow in are provided at the outer wall so that the air flowed into the premixing flow passage forms swirling flow with respect to the premixing nozzles; and the opening portions are disposed in circumferential direction and are provided one for every adjacent two premixing nozzles and the rotating directions of the swirling flows for the respective two premixing nozzles are caused to direct opposite direction each other.

A gas turbine combustor according to still another aspect of the present invention comprises: diffusive combustion nozzles which inject fuel and air

into a combustion chamber and form a diffusive combustion flame; an inner cylinder arranged outside the diffusive combustion nozzles; a plurality of premixing nozzles which are arranged outside the inner cylinder circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber; and means for forming respective swirling flows of different rotating direction for the adjacent two premixing nozzles in circumferential direction.

A gas turbine combustor according to a further aspect of the present invention comprising diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular premixing flow passage and premixing nozzles which are disposed in the premixing flow passages and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, is characterized in that a plurality of the premixing nozzles are arranged in the premixing flow passage; and opening portions permitting air to flow in are provided at the outer wall so that the air flowed into the premixing flow passage forms swirling flows for the adjacent two premixing nozzles.

A gas turbine combustor according to a still further aspect of the present invention comprising

diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular premixing flow passage and premixing nozzles which are disposed in the premixing flow passage and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, is characterized in that a plurality of the premixing nozzles are arranged in the premixing flow passage; opening portions permitting air to flow in into the premixing flow passage are provided at the outer wall and at portions between adjacent two premixing nozzles in the circumferential direction; and isolation wall members which are provided respectively at both sides of the adjacent two premixing nozzles in the circumferential direction.

A gas turbine combustor according to a still further aspect of the present invention comprises: diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame; an inner cylinder arranged outside the diffusive combustion nozzles; a plurality of premixing nozzles arranged outside the inner cylinder in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber;

means for forming respective swirling flows of different rotating direction for the adjacent two premixing nozzles in circumferential direction; and a member which surrounds the adjacent two premixing nozzles in the circumferential direction along the axial direction thereof.

A gas turbine combustor according to a still further aspect of the present invention comprising diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular premixing flow passage and premixing nozzles which are disposed in the premixing flow passage and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, is characterized in that a plurality of the premixing nozzles are arranged in the premixing flow passage; and opening portions permitting air to flow in are provided at the outer wall so that the air flowed into the premixing flow passage forms swirling flows with respect to the premixing nozzles, thereby, the rotating directions of the swirling flows for the respective two premixing nozzles are caused to direct opposite directions each other.

A gas turbine combustor according to a still further aspect of the present invention comprises

diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular premixing flow passage and premixing nozzles which are disposed in the premixing flow passage and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, wherein a plurality of the premixing nozzles are arranged in the premixing flow passage; opening portions permitting air to flow in are provided at the outer wall so that the air flowed into the premixing flow passage forms swirling flow with respect to the premixing nozzles; and each of the opening portions is configured in nearly a triangular shape in such a manner either that the opening broadens in the main air stream direction prior to flowing into the premixer or that the opening decreases in the main air stream direction prior to flowing into the premixer; and the rotating directions of the swirling flows for the respective two premixing nozzles are caused to direct opposite directions each other.

A gas turbine combustor use premixing device according to one aspect of the present invention comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas

formed by premixing fuel and air into a combustion chamber, is characterized in that one air flow inlet for every adjacent two premixing nozzles is provided so that a swirling flow is formed for the respective adjacent two premixing nozzles in the circumferential direction.

A gas turbine combustor use premixing device according to another aspect of the present invention comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into a combustion chamber, is characterized in that one air flow inlet for every adjacent two premixing nozzles is provided so that swirling flows of which rotating directions are opposite each other are formed for the respective adjacent two premixing nozzles in the circumferential direction.

A gas turbine combustor use premixing device according to still another aspect of the present invention comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into a combustion chamber, is characterized in that means is provided which forms swirling flows of which rotating directions are different for the respective adjacent

two premixing nozzles in the circumferential direction.

A premixing method for a gas turbine combustor according to one aspect of the present invention comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into a combustion chamber, is characterized in that air is flown from air flow inlets each being provided for every adjacent two premixing nozzles in the circumferential direction, and swirling flows are formed around the respective adjacent two premixing nozzles.

A premixing method for a gas turbine combustor according to another aspect of the present invention comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into a combustion chamber, is characterized in that air is flown from air flow inlets each being provided for every adjacent two premixing nozzles, and swirling flows of which rotating directions are opposite each other are formed around the respective adjacent two premixing nozzles.

A premixing method for a gas turbine combustor according to still another aspect of the present invention comprising a plurality of premixing nozzles

which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into a combustion chamber, is characterized in that one air flow inlet for every adjacent two premixing nozzles is provided so that swirling flows of which rotating directions are different each other are formed around the respective adjacent two premixing nozzles in the circumferential direction.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a partial transversal cross sectional view of a combustor representing one embodiment of the present invention;

Fig. 2 shows a partial top plane view of the combustor representing the embodiment of the present invention;

Fig. 3 shows a partial vertical cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 4 shows another partial vertical cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 5 shows another partial transversal cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 6 shows a cross sectional view of the entire

structure of the combustor representing the embodiment of the present invention;

Fig. 7 shows a partial transversal cross sectional view of a combustor representing one embodiment of the present invention;

Fig. 8 shows a partial vertical cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 9 shows a partial top plane view of the combustor representing the embodiment of the present invention;

Fig. 10 shows a partial transversal cross sectional view of a combustor representing one embodiment of the present invention;

Fig. 11 shows a partial vertical cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 12 shows a partial top plane view of the combustor representing the embodiment of the present invention;

Fig. 13 shows a partial transversal cross sectional view of a combustor representing one embodiment of the present invention;

Fig. 14 shows a partial vertical cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 15 shows a partial top plane view of the

combustor representing the embodiment of the present invention;

Fig. 16 shows a partial transversal cross sectional view of a combustor representing one embodiment of the present invention;

Fig. 17 shows a partial vertical cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 18 shows a partial top plane view of the combustor representing the embodiment of the present invention;

Fig. 19 shows a partial transversal cross sectional view of a combustor representing one embodiment of the present invention;

Fig. 20 shows a partial vertical cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 21 shows a partial top plane view of the combustor representing the embodiment of the present invention;

Fig. 22 shows a partial transversal cross sectional view of a combustor representing one embodiment of the present invention;

Fig. 23 shows a partial vertical cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 24 shows a partial top plane view of the

combustor representing the embodiment of the present invention;

Fig. 25 shows a partial top plane view of a combustor representing one embodiment of the present invention;

Fig. 26 shows a partial top plane view of a combustor representing another embodiment of the present invention;

Fig. 27 shows a partial transversal cross sectional view of a comparator representing still another embodiment of the present invention;

Fig. 28 shows a partial vertical cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 29 shows a partial top plane view of the combustor representing the embodiment of the present invention;

Fig. 30 is a diagram in which swirling intensities of three embodiments are compared;

Fig. 31 is a diagram in which attenuations of the swirling intensities of three embodiments are compared using embodiment 2 as reference;

Fig. 32 shows a partial vertical cross sectional view of a combustor to which the present invention is applied;

Fig. 33 shows a partial transversal cross sectional view of the combustor to which the present

invention is applied;

Fig. 34 shows a partial top plane view of the combustor representing the embodiment of the invention;

Fig. 35 shows a partial vertical cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 36 shows a partial transversal cross sectional view of the combustor representing the embodiment of the present invention;

Fig. 37 shows a partial top plane view of a combustor representing a further embodiment of the present invention;

Fig. 38 is a partial transversal cross sectional view of the combustor representing the embodiment of the present invention; and

Fig. 39 is a partial top plane view of a combustor representing a still further embodiment of the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

Hereinbelow, embodiments of the present invention will be explained.

In the embodiments of the present invention, a measure is taken that an inlet window is configured in such a manner that the width in circumferential direction of the inlet window varies along the axial

direction of a combustor and thereby, such as strength and size of swirls can be controlled so as to obtain the maximum effect.

Further, for the fuel nozzles arranged along the circumferential direction in a premixer one inlet window is assigned for two pieces of the fuel nozzles to form one set so that each set thereof causes to generate a pair of two swirls, thereby number of inlet windows is relatively reduced as well as partition walls in the premixer is also reduced which prevent attenuation of the swirls and further advances the mixing.

Through the reduction of the inlet windows and the partition walls in the premixer the manufacturing cost thereof can be reduced as well as through strengthening and optimizing the swirl further highly uniform premixing gas can be obtained and a combustor showing an excellent low NOx performance can be provided.

(Embodiment 1)

Hereinbelow, a first embodiment of the present invention will be explained with reference to Fig. 1 through Fig. 6.

Fig. 6 is a cross sectional view of an entire structure of a combustor. The present combustor is an example in which the diffusive combustion showing an excellent stability is preformed at the center portion

thereof and the premixing combustion showing an excellent low NOx property is preformed at the outer circumferential side thereof, thereby, a lowering of NOx is achieved.

As shown in Fig. 6, in the combustor air 50 sent from the compressor 10 flows between a combustor outer cylinder 2 and a combustor liner 3. Then, a part of the air flows in into a combustion chamber 1 as cooling air 51 for the combustor liner 3 and a part of the other air flows in into a premixer 12 as premixing use air 49. The remaining air flows in into the combustion chamber 1 from a combustion air hole 14a and a cooling air holes 17 via a passage between the premixer and a combustor end plate.

Further, diffusive combustion use fuel 16 is injected into the combustion chamber 1 from diffusion fuel nozzles 13 to from a stable diffusive flame 4. Premixing use fuel 21 is injected from premixing fuel nozzles 8 into an annular shaped premixer 12 to form premixed gas 22 by mixing with air. The premixed gas 22 flows out into the combustor 1 to form a premixing flame 5. Then, the generated high temperature combustion gas is introduced into a turbine 18 to perform works and thereafter exhausted.

In a low NOx combustor making use of such premixing combustion, formation of uniform premixed gas greatly affects the low NOx performance. In

particular, in the above conventional example which is structured in such a manner that the air flow makes a U turn at the inlet of the premixer, a drift with regard to air flow is likely caused which makes difficult to form a uniform mixing gas. Namely, for such measure it requires great attention of advancing the mixing in the premixer.

A partial vertical view of a combustor to which the present invention is applied is shown in Fig. 4, and a partial transversal cross sectional view of the combustor to which the present invention is applied is shown in Fig. 5. The premixing device of the present embodiment is provided with, as shown in Fig. 4 and Fig. 5, the combustor outer cylinder 2, the cylindrical shaped combustor liner 3, the premixer 12 including an annular passage for flowing the gas into the combustor 1, an annular air passage 203 formed by these elements, air inlet opening portions 30 arranged at the outer circumferential side of the premixer 12 and serving as air inlet windows, a plurality of premixing fuel nozzles 8 arranged in the premixer annular passage along the circumferential direction thereof, fuel injection holes 81 bored at the premixing fuel nozzles 81 and a plurality of partitions 31 arranged in the premixer annular passage along the circumferential direction thereof and serving as partition walls.

The combustor outer cylinder 2 is for preventing the high temperature and high pressure air 50 from leaking to the outer atmosphere and for securing combustor members to a gas turbine main body. The combustor liner 3 forms the combustor 1, and of which inner portion combustion reaction between fuel and air is performed to generate high temperature combustion gas and which introduces the high temperature combustion gas to the turbine.

The premixer 12 forms an annular passage, forms the premixed gas 22 in the passage by mixing the fuel and air, flows out the same into the combustor 1, and causes to perform premixing combustion with limited amount of NOx exhaustion.

The air passage 203 is an annular passage for passing the high temperature and high pressure air to the premixer 12.

A plurality of premixing fuel nozzles 8 are arranged in the annular passage near the inlet of the premixer 12 along the circumferential direction thereof so as to properly distribute the fuel, and each of the fuel nozzles 8 is provided with not less than one fuel injection port 81 through which fuel is injected into the premixer 12.

The partitions 31 serving as isolation walls mechanically support the inner and outer circumferential walls of the premixer 12 as well as

partition the annular passage of the premixer 12 into a plurality of chambers in circumferential direction thereof.

Now, the present invention will be explained with reference to Fig. 1 through Fig. 3. Fig. 1 shows a partial transversal cross sectional view of a combustor representing one embodiment of the present invention, Fig. 2 shows a partial top plane view of the combustor representing the one embodiment of the present invention and Fig. 3 shows a partial vertical cross sectional view of the combustor representing the one embodiment of the present invention.

In the present embodiment, an air inlet opening portions 30 serving as an air inlet windows form inlet ports through which air flows in from the air passage 203 to the premixer 12, the opening portions are distributedly arranged along the circumferential direction in a rate of for every one opening portion two pieces of fuel nozzles 8 and each of the main opening area is arranged so as to locate at the intermediate position in circumferential direction of the two pieces of fuel nozzles.

The width of the opening portion is configured to gradually decrease in the main air flow direction flowing through the air passage 203, thereby, the opening portions are configured nearly a rectangular shape.

Now, an operation of the embodiment of the present invention will be explained. As shown in Fig. 4, the high temperature and high pressure air 50 sent from the compressor passes through the annular passage 203 formed by the combustor outer cylinder 2, the combustor liner 3 and the premixer 12 and reaches the air inlet opening portions 30 of the premixer 12, where the air 50 is branched into premixing use air 49 flowing into the premixer 12 and air 14 flowing into such as the diffusive combustor.

As shown in Fig. 1, the premixing use air 49 entered into the premixer 12 inverts the flow direction so as to flow along the flow passage of the premixer 12, forms the premixed gas while being mixed with premixing fuel 21 injected from the fuel injection holes 81 of the fuel nozzles 8 disposed in the premixer 12, and then flows out into combustor 1.

In the combustor 1, premixing flame is formed by making use of the high temperature gas in the diffusive combustor at the upstream side as an ignition source or by making use of a proper flame holder (such as a bluff body), and a premixing combustion reaction with limited NOx generation is performed to generate high temperature combustion gas.

Herein, the higher the uniformity of the fuel density in the premixed gas 21, the more the uniformity of temperature of the combustion gas is

achieved, thereby a low NOx combustion can be realized while eliminating a high temperature portion which operates as NOx generation source.

Now, processes of mixing fuel and air in the present embodiment will be explained in detail with reference to Fig. 7 through Fig. 24.

At first, configuration of the air inlet window and air flow caused in the premixer will be explained with reference to Fig. 7 through Fig. 12.

As shown in Fig. 7 through Fig. 9 the premixing use air 49 entered into the premixer 12 inverts the flow direction so as to flow along the flow passage of the premixer 12, forms the premixed gas while being mixed with premixing fuel 21 injected from the fuel injection holes 81 of the fuel nozzles 8 disposed in the premixer 12, and then flows out into the combustor 1. Herein, for simplicity's sake, at first only the air flow will be explained while omitting the fuel nozzles. As shown in Fig. 9, when the window is configured in a one large continuous opening along the entire circumferential direction, namely, the air inlet opening portions 30 are provided continuously along the circumferential direction, as shown in Figs. 7 and 8, the air flow in the premixer 12 assumes a laminar air flow with small secondary flow in the flow passage cross section and the mixing between fuel and air is not sufficiently advanced. Further, along the

inner surface of the premixer outer circumferential side wall where the air flow is inverted break away vortexes having axis in circumferential direction are likely caused. Since these vortexes are unstable and occasionally break away and are discharged toward downstream while being carried on the air flow, these vortexes are considered as one of the causes which induces a back fire phenomenon causing flame at the downstream side.

On the other hand, as shown in Fig. 10 through Fig. 12, in the present embodiment, the opening portions are distributed along the circumferential direction. Namely, the air inlet opening portions 30 are provided discontinuously along the circumferential direction. Therefore, as shown in Figs. 10 and 11, a negative pressure region 300 is formed due to flow break away at the back face between the adjacent two air inlet openings 30 serving as inlet air windows and a pair of stable vortexes 301 are formed around the negative pressure region 300. Further, as shown in Fig. 10, the swirling directions of the generated adjacent vortexes 301 are opposite direction each other when seen along the circumferential direction of the combustor. These vortexes 301 extend downstream side in the axial direction while gradually attenuating due to friction loss with the inner face of the premixer wall, greatly agitate the air in the

flow passage cross section in the premixer and advance mixing between fuel and air.

Now, with reference to Figs. 13 through 15 and Figs. 16 through 18, difference in effect, when the opening width of the air inlet opening portions 30 serving as air inlet windows is varied in the main flow direction of the air, will be explained. Fig. 13 is a partial transversal cross sectional view of the combustor representing the one embodiment of the present invention, Fig. 14 is a partial vertical cross sectional view of the combustor representing the one embodiment of the present invention, and Fig. 15 is a partial top plane view of the combustor representing the one embodiment of the present invention.

The embodiment as shown in Figs. 13 through 15 illustrates a state of the vortexes 301 when the opening portions are configured nearly triangular shape in such a manner that the width thereof gradually decreases in the main flow direction of the air 50 in the air flow passage 203 (directing in opposite direction from the premixing air flow direction). In this instance, the vortexes spread entirely toward the inner circumferential side of the premixer flow passage and a further strong agitating and mixing action can be obtained.

Further, Fig. 16 is a partial transversal cross sectional view of the combustor representing the one

embodiment of the present invention, Fig. 17 is a partial vertical cross sectional view of the combustor representing the one embodiment of the present invention, and Fig. 18 is a partial top plane view of the combustor representing the one embodiment of the present invention.

The embodiment as shown in Figs. 16 through 18 illustrates a state of the vortexes 301 when the opening portions are configured in such a manner that contrary to the above the width thereof gradually increases in the main air flow direction in the air flow passage 203 in the manner broadening along the stream. In this instance, the vortexes 301 are relatively confined at the outer circumferential side of the premixer and the agitating and mixing action thereof is also comparatively small.

In a case when the configuration of the air inlet window is not varied in the flow direction which corresponds to the example as shown in Figs. 10 through 12, the agitating and mixing action thereof shows an intermediate one of the above explained two examples.

As has been explained above, through distribution of the premixer air inlet windows 30 in circumferential direction and formation in the premixer of a pair of vortexes of which swirling directions are opposing each other, the mixing between

fuel and air in the premixer can be advanced.

Further, through configuring the air inlet opening portions 30 serving as the premixer air inlet window nearly a triangular shape in such a manner the width thereof gradually decreases in the flow direction of the air 50, the size and strength of the vortexes 301 can be increased, thereby, the agitating and mixing action thereof is further strengthened.

Now, a relationship between position of the air inlet window 30 and premixing fuel nozzles 18 and mixing process will be explained with reference to Figs. 19 through 21 and Figs. 22 through 24. Fig. 19 is a partial transversal cross sectional view of the combustor representing the one embodiment of the present invention, Fig. 20 is a partial vertical cross sectional view of the combustor representing the one embodiment of the present invention, and Fig. 21 is a partial top plane view of the combustor representing the one embodiment of the present invention, Fig. 22 is a partial transversal cross sectional view of the combustor representing the one embodiment of the present invention, Fig. 23 is a partial vertical cross sectional view of the combustor representing the one embodiment of the present invention, and Fig. 24 is a partial top plane view of the combustor representing the one embodiment of the present invention.

In Figs. 19 through 21, the premixing fuel

nozzles 8 are disposed so as to locate immediately below the centers of the air inlet windows 30. Namely, the premixing fuel nozzles 8 are located substantially on the lines connecting between the air inlet windows 30 and the axial center of the combustor. In this instance, the vortexes 301 are formed between the adjacent premixing fuel nozzles 8, however, the premixing fuel nozzles 8 operate so as to disturb the main flow of the premixing use air 49 therefore, the vortexes 301 are comparatively small and gentle.

On the other hand, Figs. 22 through 24 relate to the embodiment of the present invention wherein the air inlet opening portions serving as the air inlet windows are disposed in such a manner the centers of the openings locate substantially the intermediate of the adjacent premixing fuel nozzles. In this instance, large and strong vortexes 301 are formed so as to surround the premixing fuel nozzles 8, thereby, an excellent agitating and mixing effect can be obtained.

In the present embodiment, for each of the premixing inlet air windows since a pair of vortexes of which swirling directions are opposing are formed, the swirling directions of the vortexes for adjacent premixer inlet air windows are also directing oppositely each other, thereby, interference

therebetween hardly occurs. Therefore, different from the conventional structure which necessitates partitions 31 serving as the isolation walls partitioning the premixer flow passage for every window along the circumferential direction, however, in the present embodiment it is sufficient if the minimum number of isolation walls is provided which maintains mechanical strength required for the premixer. Namely, the partition can be omitted to take an easy structure or the partitions 31 can be simplified. Generally, a major cause of attenuation of the vortexes 301 which advance the mixing is an attenuation due to friction loss with the premixer walls, with the premixer inlet air windows according to the present embodiment the attenuation of the formed vortexes can be extremely limited, thereby, further uniform premixed gas can be formed.

To put this differently, the length of the premixer necessary for obtaining the premixed gas having the same uniformity can be shortened and effect of cost reduction and freedom for designing can be enhanced.

Further, the unstable break away vortexes in the circumferential direction are hardly formed which possibly contributes to reduce negative potentials such as back fire.

At the same time, as in the present embodiment,

the number of isolation walls can be minimized, which also contributes manufacturing cost reduction.

(Embodiment 2)

A second embodiment of the present invention will be explained with reference to Fig. 25. Although the basic structure of the present invention is the same as that of the first embodiment, a different point thereof is that the width of the air inlet opening portions 30 is kept unchanged in the main flow direction of air. Through thus constituting, although the agitating and mixing performance thereof somewhat reduces as has been explained above, easiness of parts manufacturing and assembling the same can be enhanced.

(Embodiment 3)

A third embodiment of the present invention will be explained with reference to Fig. 26. Although the basic structure of the present invention is the same as that of the first embodiment, a different point thereof is that the air inlet opening portions 30 are configured into nearly a triangular shape in such a manner that the width thereof is broadened in the main flow direction of the air. Through thus constituting, the swirling vortex generation sources at the downstream side of the windows are limited in a narrow range in comparison with other embodiments as has been explained above and comparatively gentle mixing can be realized and the present embodiment is effective in a

case where the mixing degree at the inner circumferential side is required to be gentle in view of interference with the diffusive combustion at the upstream side.

Now, comparison result of swirling intensity of vortexes with regard to the above embodiments 1 through 3 will be explained with reference to Fig. 30. Fig. 30 is a diagram in which the swirling intensities of these are compared. The abscissa represents axial direction distance from the premixing nozzle injection hole with no dimension and the ordinate represents swirl intensity.

These swirling intensities are higher than conventional ones and the attenuation of the swirling intensity in the axial direction is low in comparison with conventional ones.

Among these, it is observed that the swirling intensity of the embodiment 1 is generally high. Namely, in the case of nearly triangular shaped opening portion wherein the width thereof gradually decreases in the main air flow direction, it is observed that the swirling intensity thereof is extremely high.

Further, with regard to the embodiments 1 through 3, comparison on attenuation of the vortex swirling intensities will be explained with reference to Fig. 31. Fig. 31 is a diagram in which the attenuation of

swirling intensities of three embodiments is compared using that of the embodiment 2 as reference. The abscissa represents axial direction distance from the premixing nozzle injection hole with no dimension, and the ordinate represents relative swirling intensity when assuming that of embodiment 2 as 1.

Among the embodiments 1 through 3, the swirling intensity of embodiment 1 is generally high and when comparing with the embodiment 2, even if the axial direction distance is prolonged, it is observed that the swirling intensity is hardly attenuated. Namely, in the case of nearly triangular shaped opening portion wherein the width thereof gradually decreases in the main air flow direction (directing in opposite direction from the premixed gas flow direction), it is observed that the swirling intensity thereof is hardly reduced.

As has been explained above, with the present embodiment the attenuation of vortexes formed by the premixer inlet air windows can be minimized and further uniform mixed gas can be formed, thereby, the present embodiment contributes to enhance low NOx performance. The length of the premixer necessary for obtaining the premixed gas having the same uniformity can be shortened and effect of cost reduction and freedom for designing can be enhanced. Further, the unstable break away vortexes in the circumferential

direction are hardly formed which possibly contributes to reduce negative potentials such as back fire. At the same time, as in the present embodiment, the number of isolation walls can be minimized, which also contributes to manufacturing cost reduction.

(Embodiment 4)

A fourth embodiment of the present invention will be explained with reference to Figs. 27 though 29. Although the basic structure of the present invention is the same as that of the first embodiment, a different point thereof is that the fuel nozzle is shortened and is disposed on the wall face of the premixer. In the case as in the present embodiment where the paired two vortexes are generated, since the swirling directions of the adjacent vortexes are always directed in opposite direction, stability of the swirling vortexes is high, therefore, it is necessarily required to extend the fuel nozzles forward, thus it is possible to dispose the fuel injection holes directly on the wall face. Through thus constructing the fuel nozzles themselves can be simplified which is effective for cost reduction.

(Embodiment 5)

Fig. 32 shows a partial vertical cross sectional view of a combustor to which the present invention is applied and Fig. 33 shows a partial transversal cross sectional view of the combustor to which the present

invention is applied. In the present embodiment, in particular, the premixing fuel 21 for the premixing fuel nozzles 8 is introduced from the same direction (toward downstream side of the main flow direction) as the diffusive combustion use fuel 16 supplied for the diffusion nozzles 13.

The premixing device includes the combustor outer cylinder 2, the cylindrical shaped combustor liner 3 and a plurality of premixing fuel nozzles 8 including the flow passages leading to the combustion chamber 1 and disposed in each of the premixer passages in the circumferential direction thereof.

The combustor outer cylinder 2 is for preventing the high temperature and high pressure air 50 from leaking to the outer atmosphere and for securing combustor members to a gas turbine main body. The combustor liner 3 forms the combustor 1, and of which inner portion combustion reaction between fuel and air is performed to generate high temperature combustion gas and which introduces the high temperature combustion gas to the turbine. In the premixer 12 a part of the air 14 and 50 sent in the main flow direction flows into the premixer flow passage as the premixing air and, in the passage premixed gas 22 is formed by mixing the fuel and air to flow out the same into the combustor 1, and thereby to cause to perform premixing combustion with limited amount of NOx

exhaustion. Further, the air 14, the other part of the air 50, is sent to the diffusion side.

A plurality of sets of premixing fuel nozzles 8, each set includes a plurality of premixing fuel nozzles 8, are arranged in the passage near the inlet of the premixer 12 along the circumferential direction thereof so as to properly distribute the fuel. The flow passages are formed for every set so as to surround the respective sets. In the present embodiment, as shown in Fig. 33, two premixing fuel nozzles 8 form one set and a flow passage which surrounds the two premixing fuel nozzles 8 (a set of premixing fuel nozzles 8) is provided for every set.

In the present embodiment as shown in Fig. 34, air inlet opening portions 30 serving as air inlet windows form inlet ports through which air flows to the premixer 12, opening portions are distributedly arranged along the circumferential direction in a rate of for every one opening portion two pieces of premixing fuel nozzles 8 and each of the main opening area is arranged so as to locate at the intermediate position in circumferential direction of the two pieces of premixing fuel nozzles. Further, the width of the opening portion is configured to gradually decrease in the main air flow direction, thereby, the opening portions are configured. Still further as shown in Figs. 35 and 36, the premixing use air 49

entered into the premixer respectively inverts the flow direction so as to flow along the flow passage of the premixer 12 to thereby form the swirling flow 301. Even with this structure, a swirling flow having high swirling intensity can be formed.

(Embodiment 6)

Figs. 37 and 38 show another configuration of the inlet window. The present embodiment is an exemplary measure in which the swirling directions of vortexes formed around the adjacent two premixing fuel nozzles 8 are direction in opposite directions each other.

Namely, for the respective adjacent two premixing fuel nozzles 8 a corresponding inlet window is formed and the opening area of the respective inlet windows is gradually reduced toward outside near from the centers of the respective premixing fuel nozzles 8. Further, each of the opening portion areas is gradually reduced in the main stream direction. With this structure, the swirling directions formed around the adjacent two premixing fuel nozzles 8 are directed in opposite directions each other and a swirling flow having high swirling intensity can be formed.

Further, when put this differently, a nearly triangular shaped inlet portion of which opening portion area is gradually decreased toward the main stream direction is provided for every adjacent two premixing fuel nozzles 8, thereby, an interrupting

portion which prevents air flow is formed near the center of the nearly rectangular shaped inlet portion. Through thus constituting, the swirling directions formed around the adjacent two premixing fuel nozzles 8 are directed in opposite directions each other and a swirling flow having high swirling intensity can be formed.

Further, the gradually reducing opening portion area toward the main stream direction of the nearly rectangular shaped inlet portion can be formed in a curved shape as shown in Fig. 39.

INDUSTRIAL FEASIBILITY

According to the present invention a premixer for gas turbine combustors, a premixing method for gas turbine combustors, a gas turbine combustor and a combustion method for gas turbines which uniformalize the premixing and show an excellent low NOx performance can be provided.

CLAIMS :

1. A gas turbine combustor comprising diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular premixing flow passage and premixing nozzles which are disposed in the premixing flow passage and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, characterized in that

a plurality of the premixing nozzles are arranged in the premixing flow passage;

opening portions permitting air to flow in are provided at the outer wall so that the air flowed into the premixing flow passage forms swirling flow with respect to the premixing nozzles; and

the opening portions are disposed in circumferential direction and are provided one for every adjacent two premixing nozzles.

2. A gas turbine combustor comprising diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular premixing flow passage and premixing nozzles which are disposed in the premixing flow passage and form a

premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, characterized in that

a plurality of the premixing nozzles are arranged in the premixing flow passage;

opening portions permitting air to flow in are provided at the outer wall so that the air flowed into the premixing flow passage forms swirling flow with respect to the premixing nozzles; and

the opening portions are disposed in circumferential direction and are provided one for every adjacent two premixing nozzles and the rotating directions of the swirling flows for the respective two premixing nozzles are caused to direct opposite directions each other.

3. A gas turbine combustor comprising:

diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame;

an inner cylinder arranged outside the diffusive combustion nozzles;

a plurality of premixing nozzles which are arranged outside the inner cylinder in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber; and

means for forming respective swirling flows of different rotating direction for the adjacent two premixing nozzles in circumferential direction.

4. A gas turbine combustor according to claim 1 or 2, characterized in that each of the opening portions is provided between the adjacent two premixing nozzles at the position in circumferential direction.

5. A gas turbine combustor according to claim 1 or 2, characterized in that each of the opening portions is configured in such a manner that the opening width in circumferential direction varies along the axial direction thereof.

6. A gas turbine combustor according to claim 5, characterized in that each of the opening portions is configured in nearly a triangular shape in such a manner either that the opening broadens in the main air stream direction prior to flowing into the premixer or that the opening decreases in the main air stream direction prior to flowing into the premixer.

7. A gas turbine combustor comprising diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular

premixing flow passage and premixing nozzles which are disposed in the premixing flow passage and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, characterized in that

a plurality of the premixing nozzles are arranged in the premixing flow passage; and

opening portions permitting air to flow in are provided at the outer wall so that the air flowed into the premixing flow passage forms swirling flows for the adjacent two premixing nozzles.

8. A gas turbine combustor comprising diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular premixing flow passage and premixing nozzles which are disposed in the premixing flow passage and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, characterized in that

a plurality of the premixing nozzles are arranged in the premixing flow passage;

opening portions permitting air to flow in into the premixing flow passage are provided at the outer wall and at positions between adjacent two premixing nozzles in the circumferential direction; and

isolation wall members which are provided respectively at both sides of the adjacent two premixing nozzles in the circumferential direction.

9. A gas turbine combustor comprising:

diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame;

an inner cylinder arranged outside the diffusive combustion nozzles;

a plurality of premixing nozzles which are arranged outside the inner cylinder in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber;

means for forming respective swirling flows of different rotating direction for the adjacent two premixing nozzles in circumferential direction; and

a member which surrounds the adjacent two premixing nozzles in the circumferential direction along the axial direction thereof.

10. A gas turbine combustor comprising diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular premixing flow passage and premixing nozzles which are

disposed in the premixing flow passage and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, characterized in that

a plurality of the premixing nozzles are arranged in the premixing flow passage; and

opening portions permitting air to flow in are provided at the outer wall so that the air flowed into the premixing flow passage forms swirling flows with respect to the premixing nozzles, thereby, the rotating directions of the swirling flows for the respective two premixing nozzles are caused to direct opposite directions each other.

11. A gas turbine combustor comprising diffusive combustion nozzles which inject fuel and air into a combustion chamber and form a diffusive combustion flame, outer and inner walls which form an annular premixing flow passage and premixing nozzles which are disposed in the premixing flow passage and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into the combustion chamber, wherein

a plurality of the premixing nozzles are arranged in the premixing flow passage;

opening portions permitting air to flow in are provided at the outer wall so that the air flowed into

the premixing flow passage forms swirling flows with respect to the premixing nozzles;

each of the opening portions is configured in nearly a triangular shape in such a manner either that the opening broadens in the main air stream direction prior to flowing into the premixer or that the opening decreases in the main air stream direction prior to flowing into the premixer; and

the rotating directions of the swirling flows for the respective two premixing nozzles are caused to direct opposite directions each other.

12. A gas turbine combustor use premixing device comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into a combustion chamber, characterized in that one air flow inlet for every adjacent two premixing nozzles is provided so that a swirling flow is formed for the respective adjacent two premixing nozzles in the circumferential direction.

13. A gas turbine combustor use premixing device comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas

formed by premixing fuel and air into a combustion chamber, characterized in that one air flow inlet for every adjacent two premixing nozzles is provided so that swirling flows of which rotating directions are opposite each other are formed for the respective adjacent two premixing nozzles in the circumferential direction.

14. A gas turbine combustor use premixing device comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into a combustion chamber, characterized in that means is provided which forms swirling flows of which rotating directions are different each other for the respective adjacent two premixing nozzles in the circumferential direction.

15. A premixing method for a gas turbine combustor comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into a combustion chamber, characterized in that air is flown from air flow inlets each being provided for every adjacent two premixing nozzles in the circumferential direction, and swirling flows are formed around the respective

adjacent two premixing nozzles.

16. A premixing method for a gas turbine combustor comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into a combustion chamber, characterized in that air is flown from air flow inlets each being provided for every adjacent two premixing nozzles, and swirling flows of which rotating directions are opposite each other are formed around the respective adjacent two premixing nozzles.

17. A premixing method for a gas turbine combustor comprising a plurality of premixing nozzles which are arranged in circumferential direction and form a premixing combustion flame by injecting premixed gas formed by premixing fuel and air into a combustion chamber, characterized in that one air flow inlet for every adjacent two premixing nozzles is provided so that swirling flows of which rotating directions are different each other are formed around the respective adjacent two premixing nozzles in the circumferential direction.

ABSTRACT

The purpose is to improve the mixture ratio of a pre-mixer by a simple arrangement to form a more uniform premixed gases so as to materialize low NOx combustion. Two fuel nozzles disposed circumferentially of a pre-mixer are combined with a single air intake window to make a set, which set is used to produce swirls in a pair, thereby expediting mixing. Further, the inlet window is shaped such that its circumferential width is changed axially of the combustor, thereby changing the strength and size of the swirls to achieve the greatest effect. By reducing both the pre-mixer inlet windows and the partition walls in number, the manufacturing cost can be reduced, and by strengthening and optimizing the swirls, a combustor with superior low NOx performance can be provided, while it is possible to reduce the length of the pre-mixer necessary to obtain the same mixture ratio, leading to a cost reduction.

FIG. 1

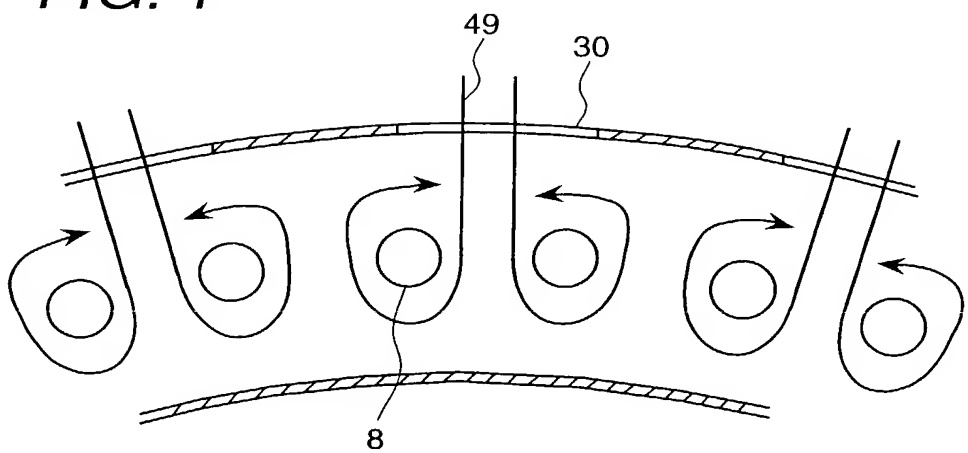


FIG. 2

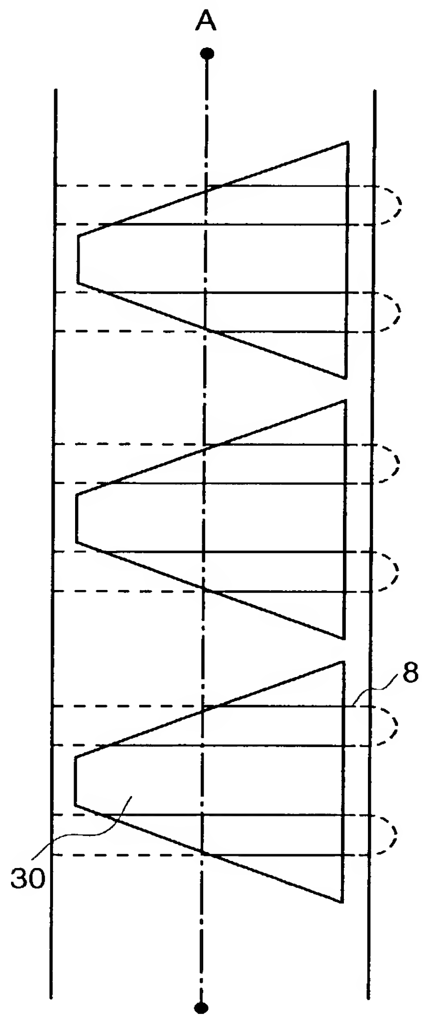


FIG. 3

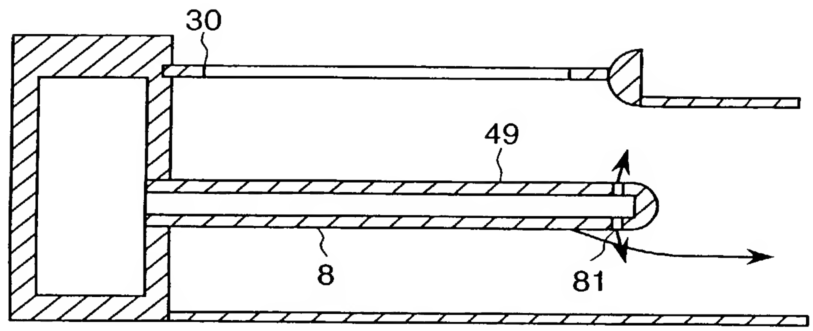


FIG. 4

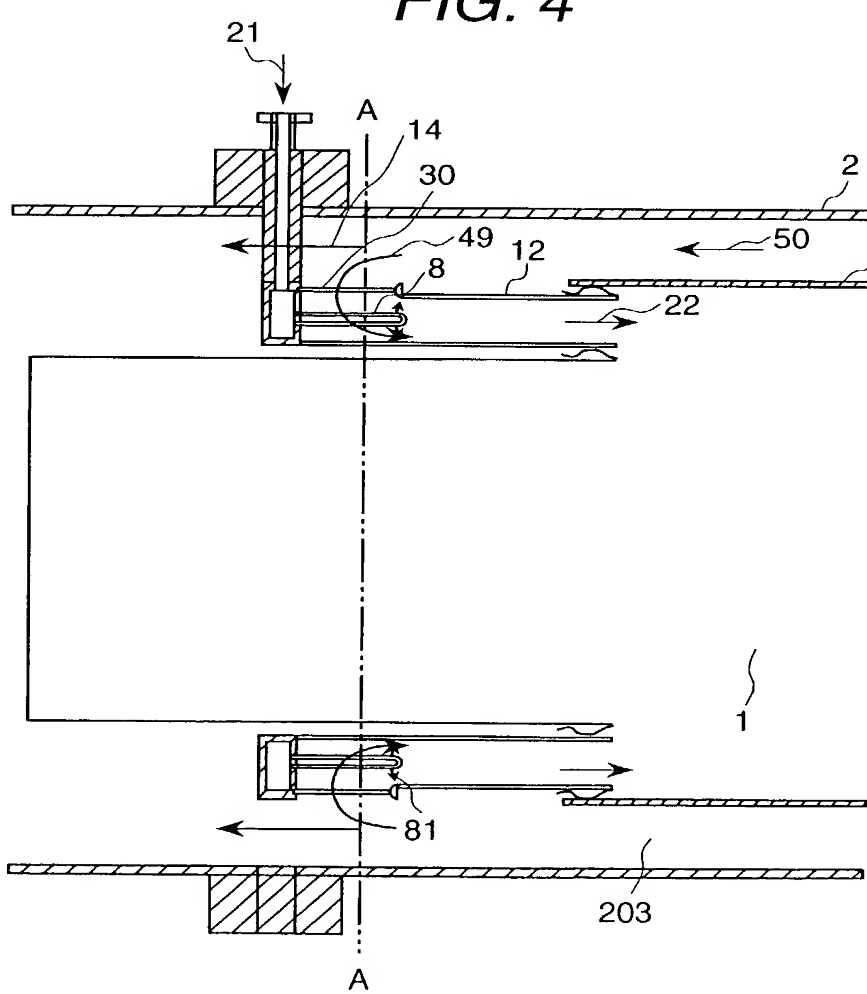
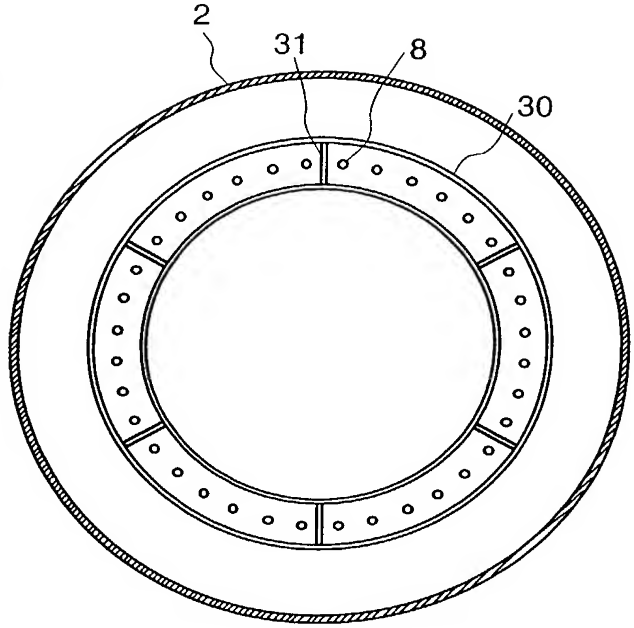


FIG. 5



A-A CROSS SECTION

FIG. 6

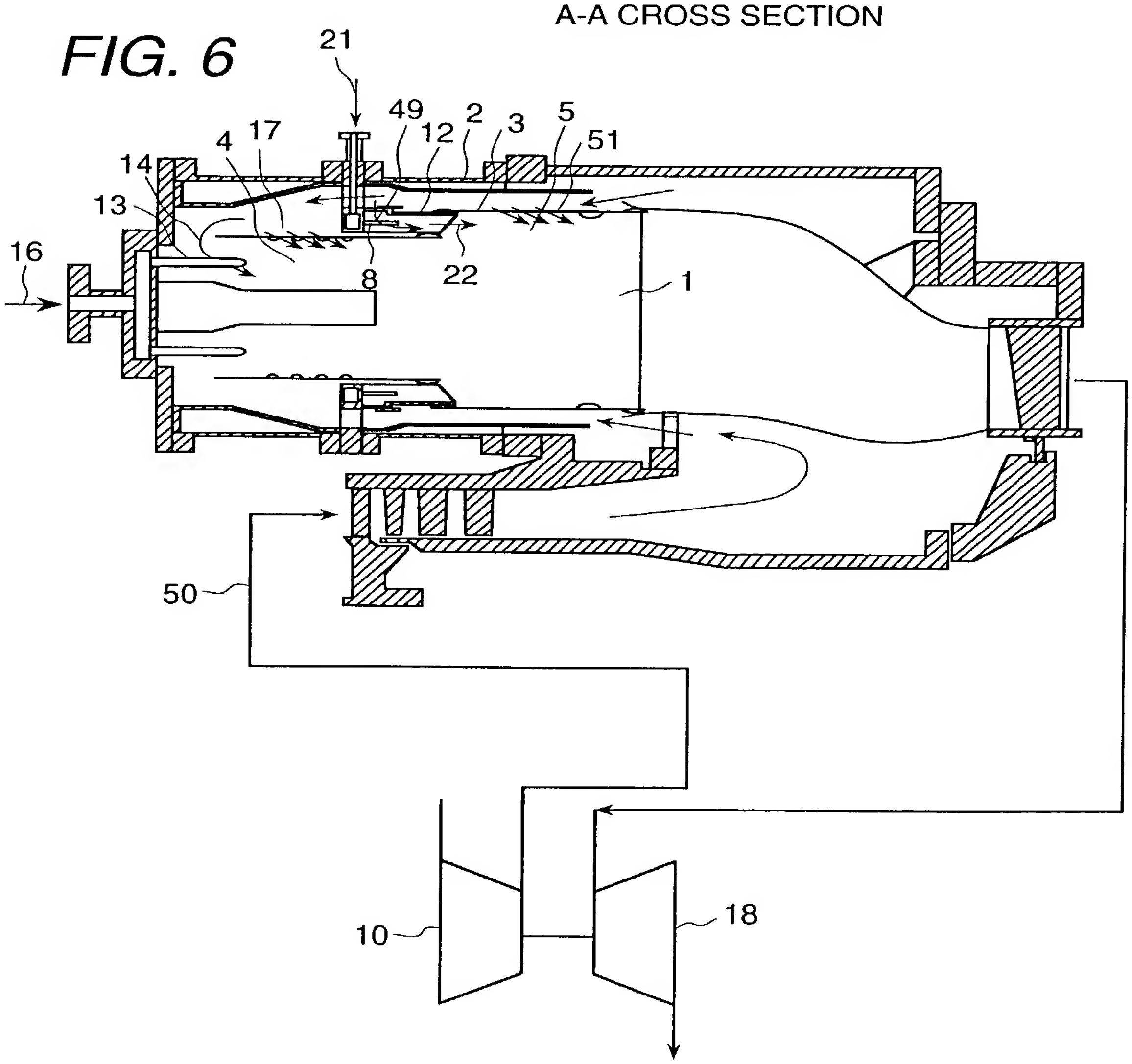
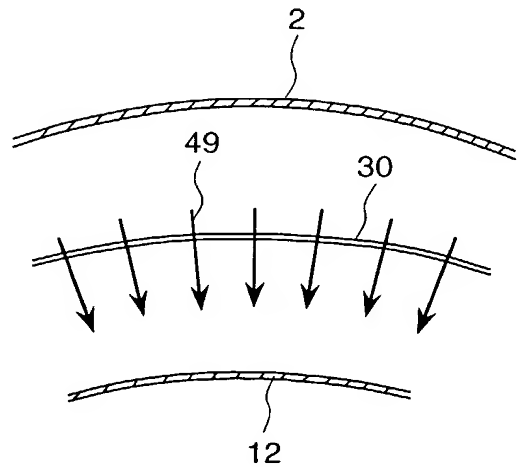


FIG. 7



A-A CROSS SECTION

FIG. 8

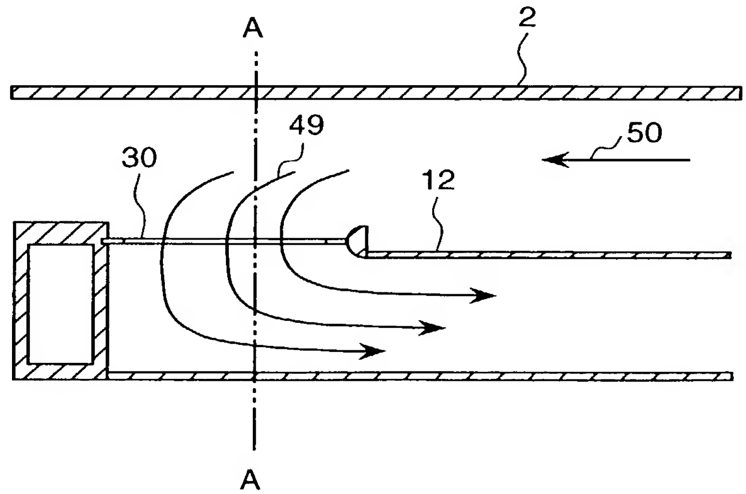


FIG. 9

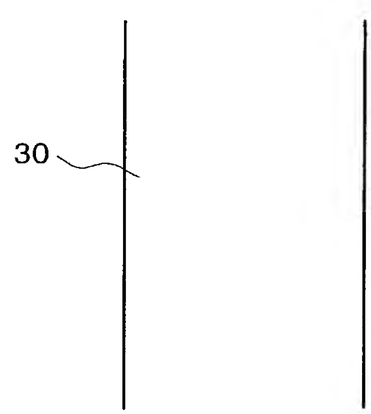


FIG. 10

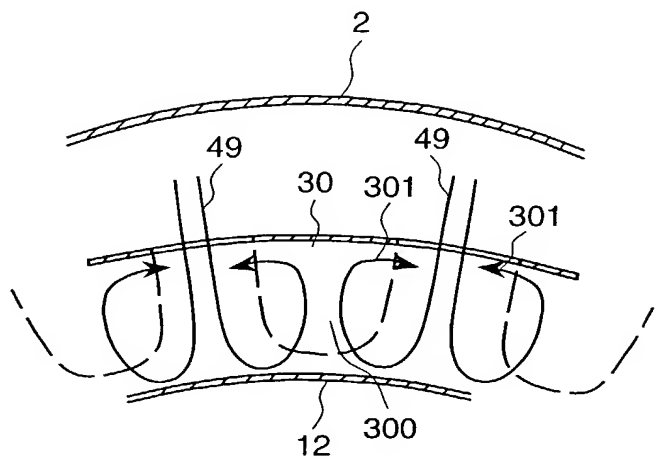


FIG. 11

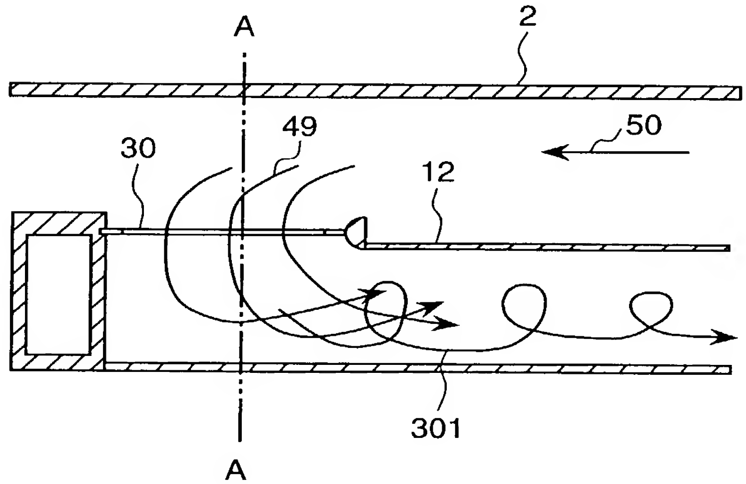


FIG. 12

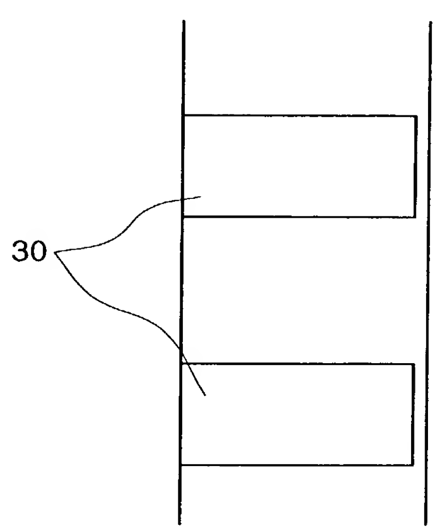
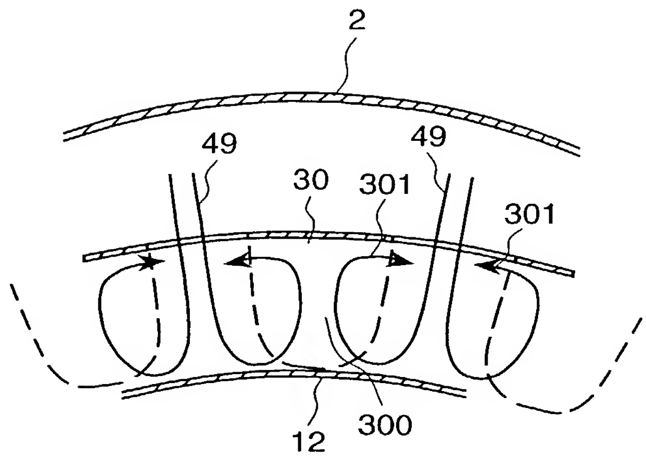


FIG. 13



A-A CROSS SECTION

FIG. 14

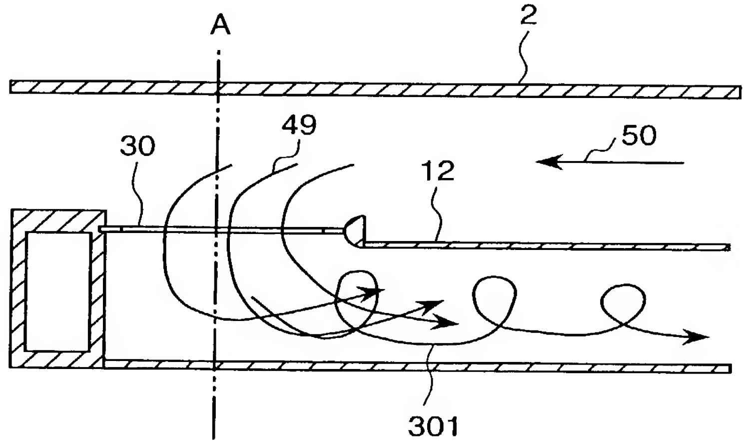


FIG. 15

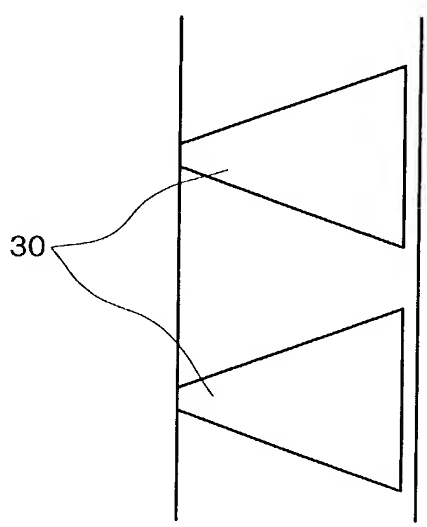
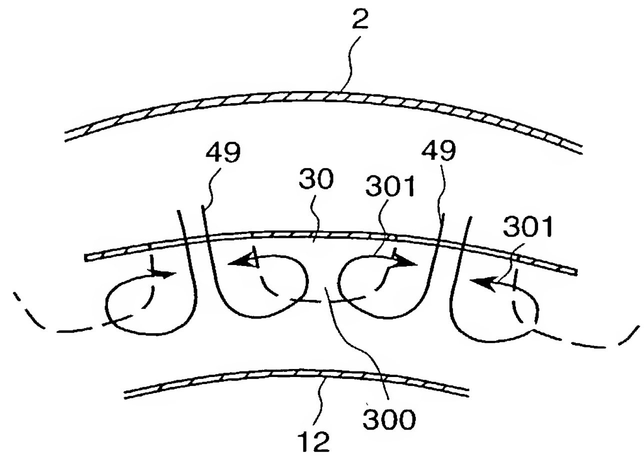


FIG. 16



A-A CROSS SECTION

FIG. 17

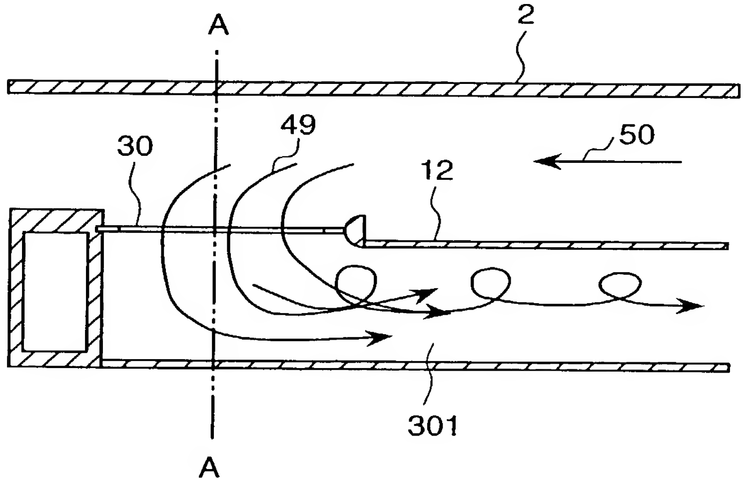


FIG. 18

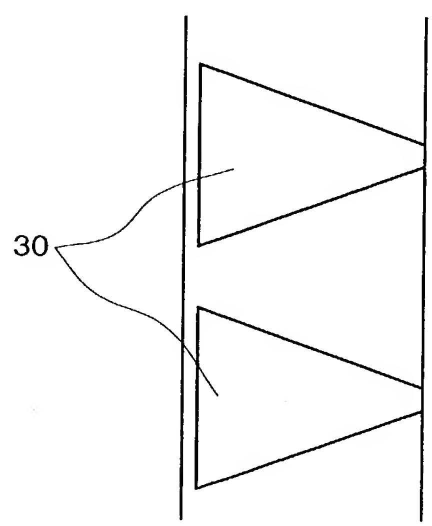
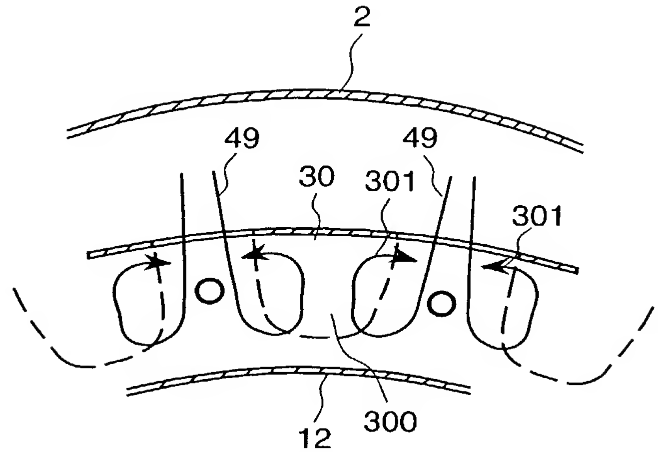


FIG. 19



A-A CROSS SECTION

FIG. 20

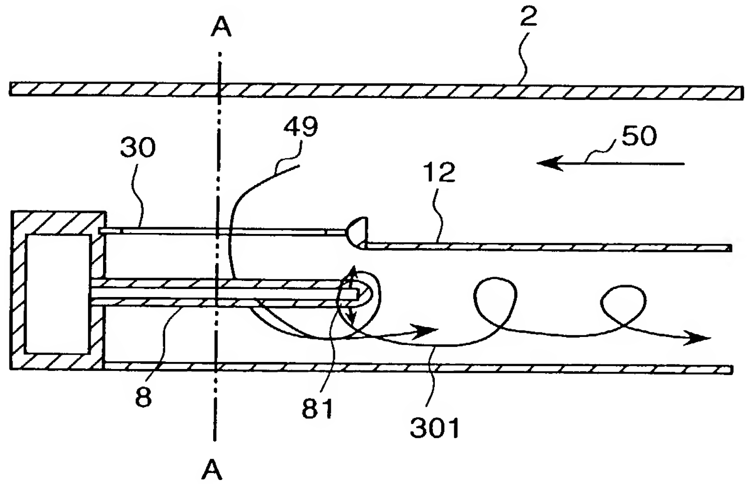


FIG. 21

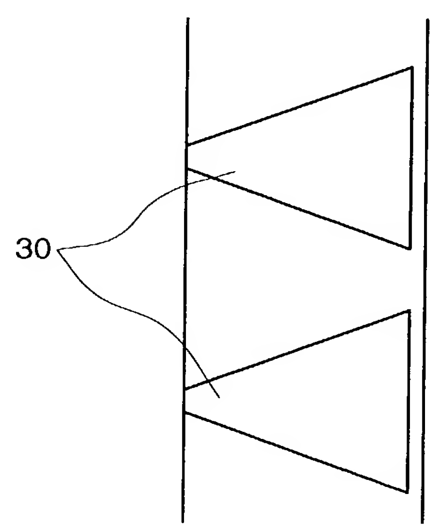
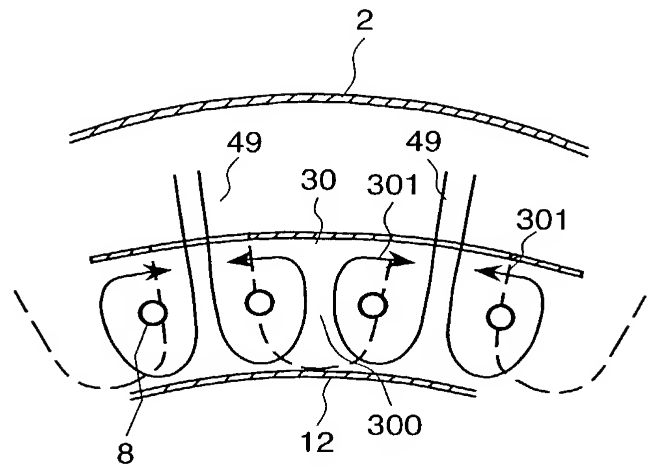


FIG. 22



A-A CROSS SECTION

FIG. 23

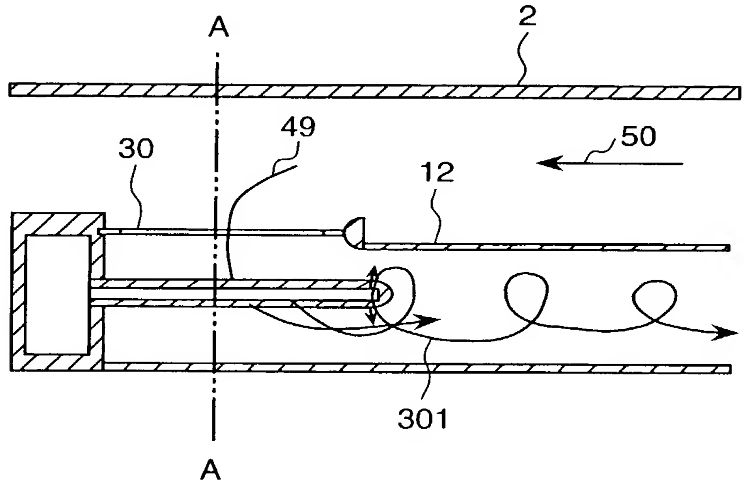


FIG. 24

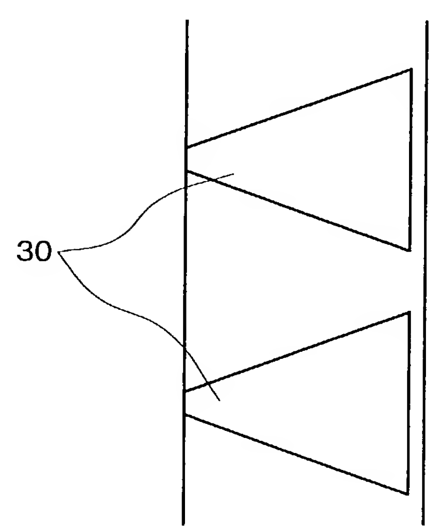


FIG. 25

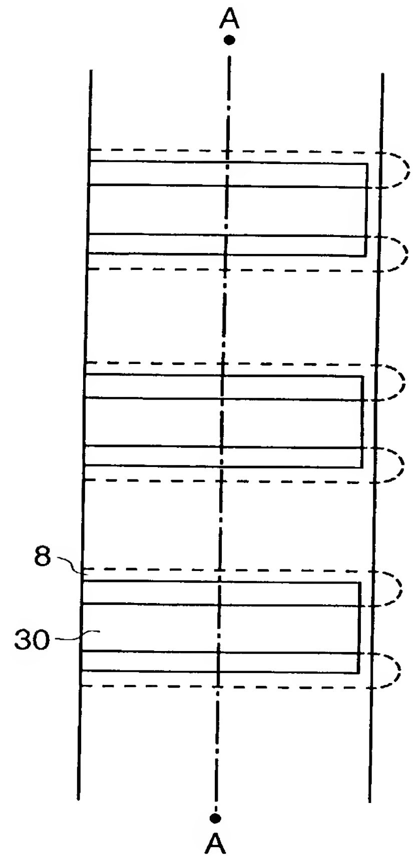


FIG. 26

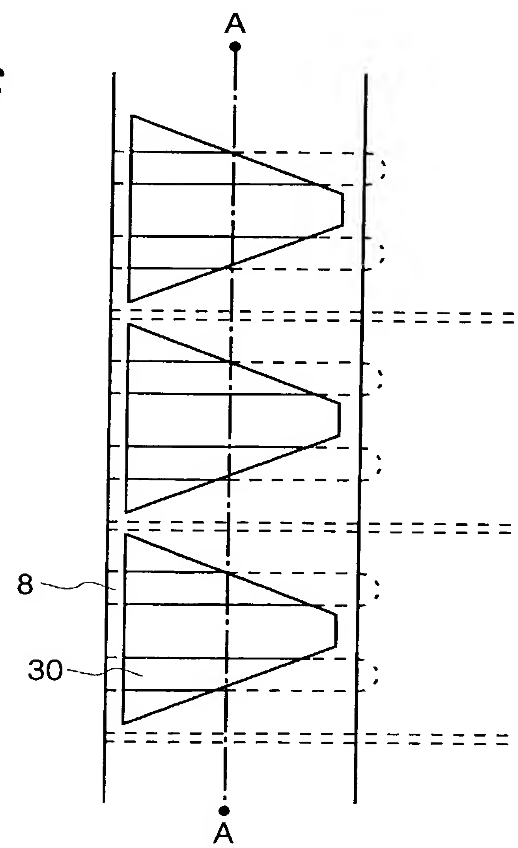
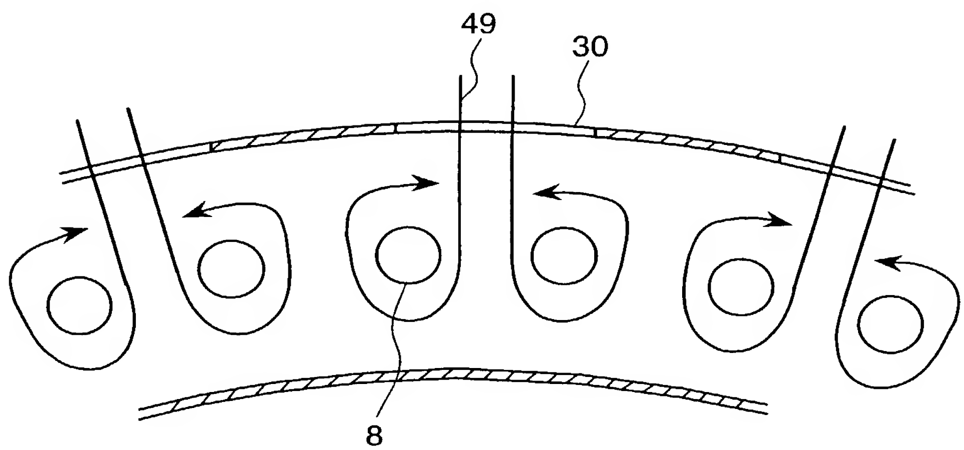


FIG. 27



A-A CROSS SECTION

FIG. 28

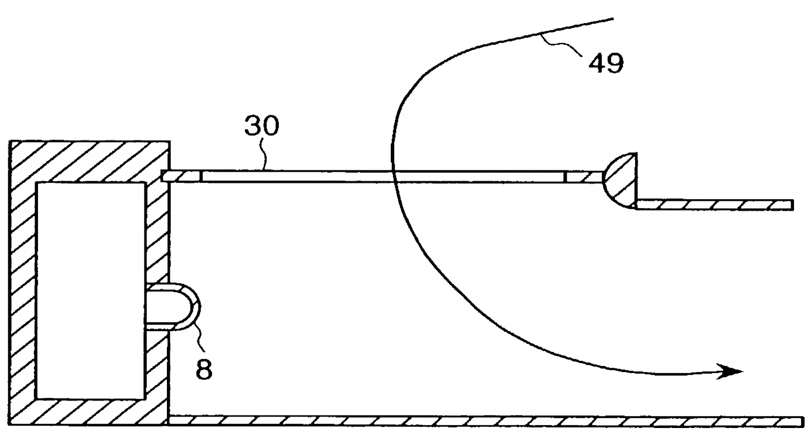


FIG. 29

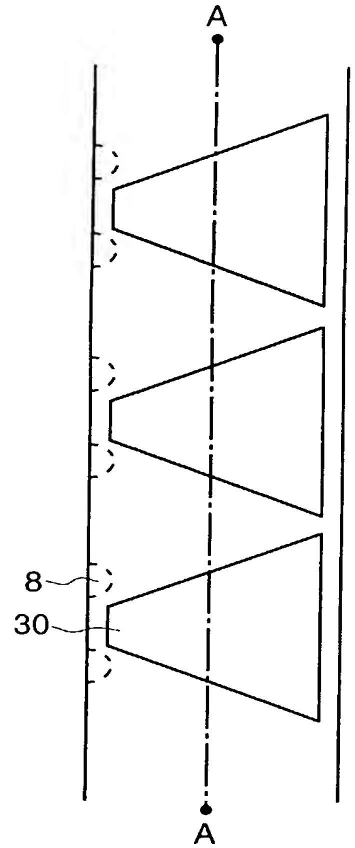

A
8
30
A

FIG. 30

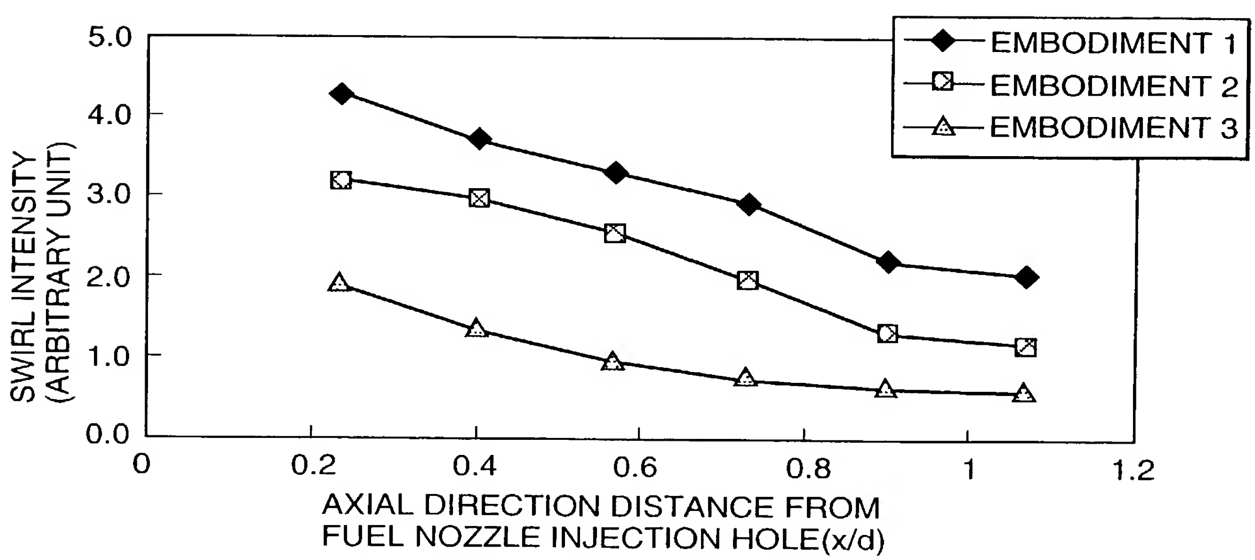

SWIRL INTENSITY (ARBITRARY UNIT)
5.0
4.0
3.0
2.0
1.0
0.0
0
0.2
0.4
0.6
0.8
1
1.2
AXIAL DIRECTION DISTANCE FROM FUEL NOZZLE INJECTION HOLE(x/d)
EMBODIMENT 1
EMBODIMENT 2
EMBODIMENT 3

FIG. 31

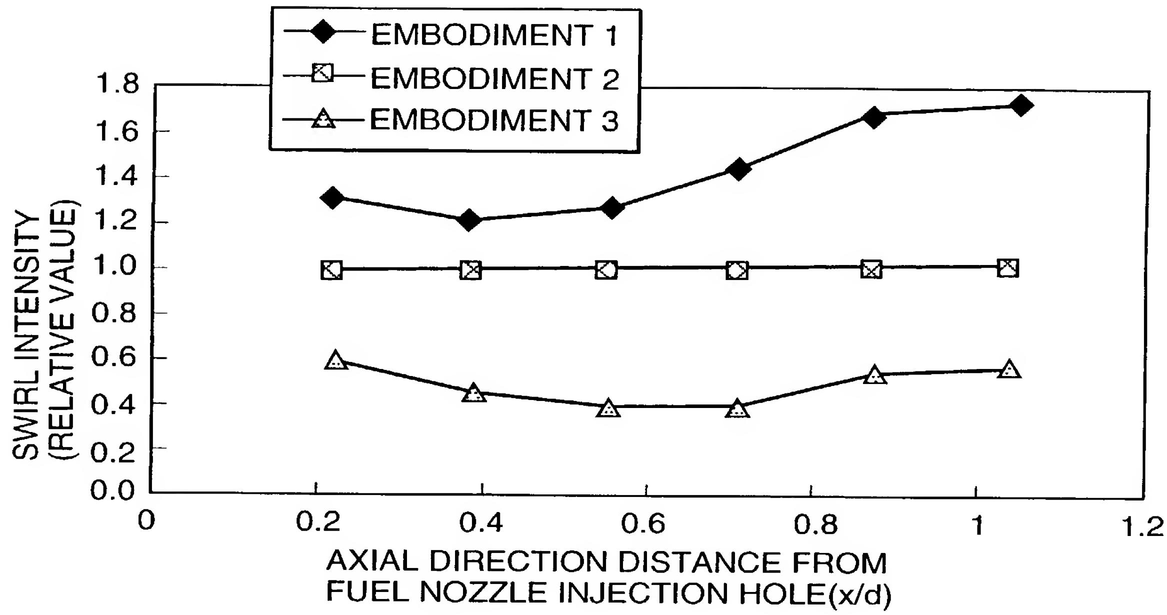

EMBODIMENT 1
EMBODIMENT 2
EMBODIMENT 3
SWIRL INTENSITY
(RELATIVE VALUE)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
0.2
0.4
0.6
0.8
1
1.2
AXIAL DIRECTION DISTANCE FROM
FUEL NOZZLE INJECTION HOLE(x/d)

FIG. 32

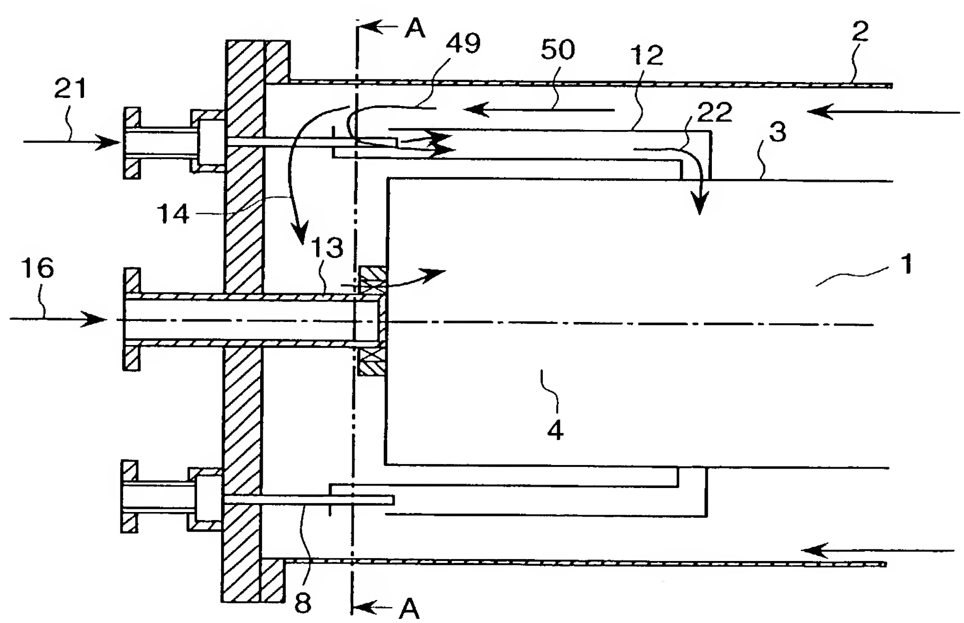

A
49
50
12
2
21
22
3
14
13
16
1
4
8
A

FIG. 33

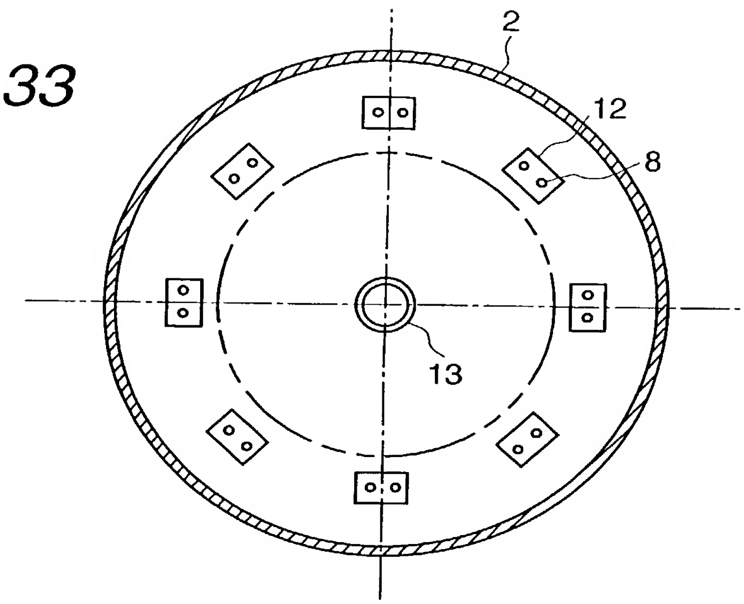


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FIG. 34

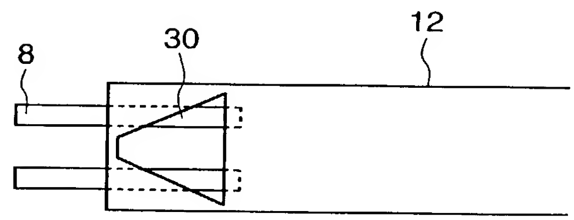


FIG. 35

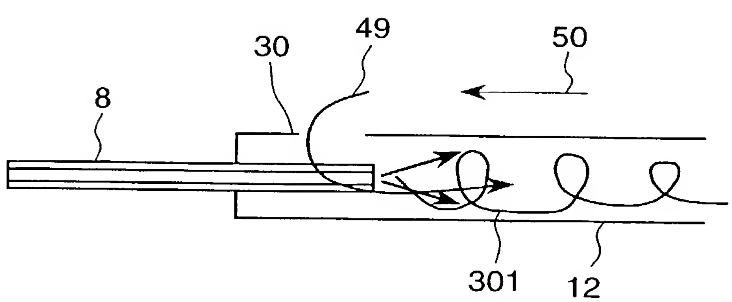


FIG. 36

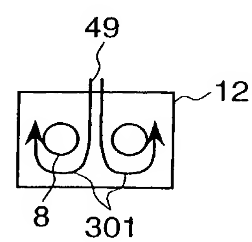


FIG. 37

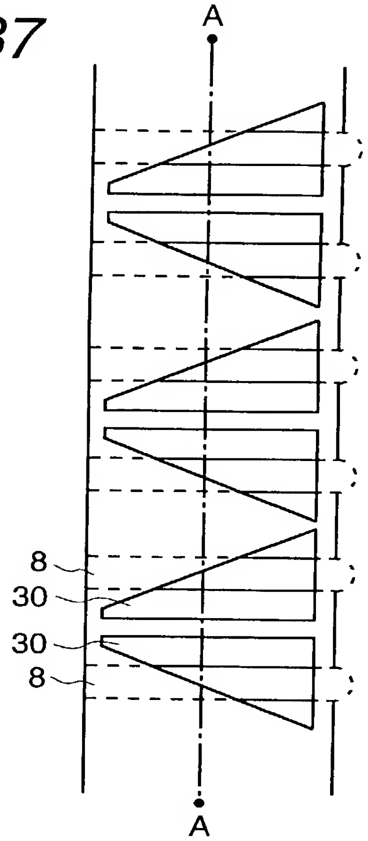


FIG. 39

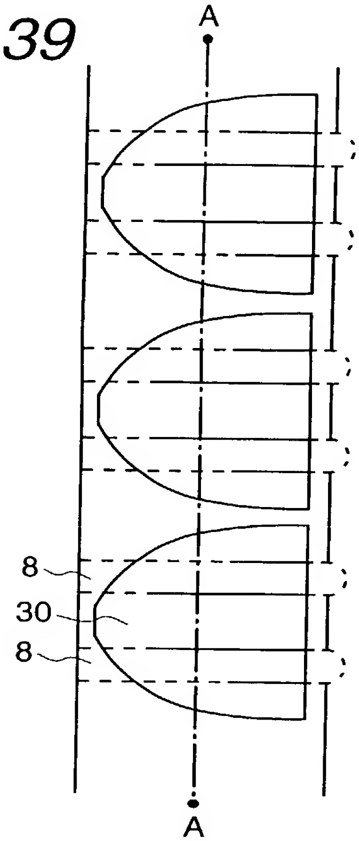
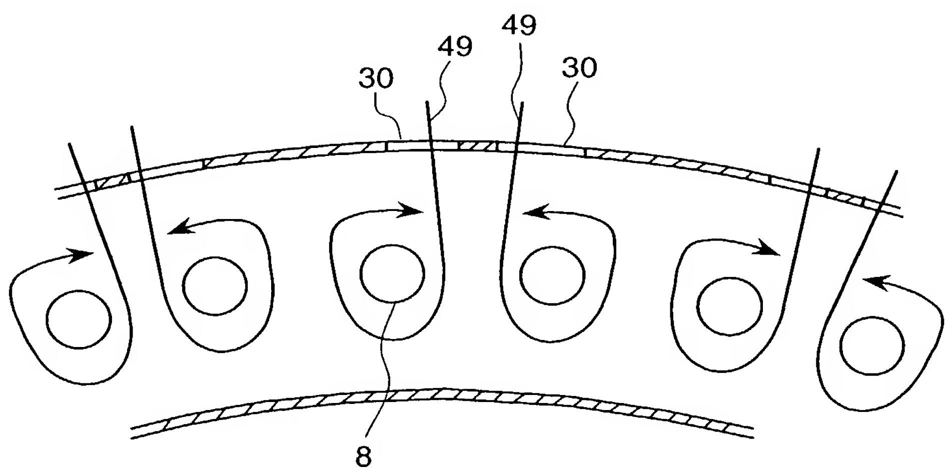


FIG. 38



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Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。	As a below named inventor, I hereby declare that:
私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。	My residence, post office address and citizenship are as stated next to my name.
下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。	I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled
____________	GAS TURBINE COMBUSTOR, PRE-MIXER FOR TURBINE COMBUSTORS AND PREMIXING METHOD FOR GAS TURBINE COMBUSTORS
上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、	The specification of which is attached hereto unless the following box is checked:
☐ __月__日に提出され、米国出願番号または特許協定条約国際出願番号を____________とし、(該当する場合) ____________に訂正されました。	☒ was filed on October 20, 1999 as United States Application Number or PCT International Application Number PCT/JP99/05779 and was amended on ____________ (if applicable).
私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。	I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.
私は、連邦規則法典第３７編第１条５６項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。	I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Burden Hour Statement This form is estimated to take 0 4 hours to complete Time will vary depending upon the needs of the individual case Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner of Patents and Trademarks, Washington, DC 20231.

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Japanese Language Declaration
(日本語宣言書)

私は、米国法典第３５編１１９条 (a) - (d) 項又は３６５条 (b) 項に基き下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約３６５ (a) 項に基ずく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示している。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
			☐
			☐

私は、第３５編米国法典１１９条 (e) 項に基いて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) (出願番号)	(Filing Date) (出願日)

私は、下記の米国法典第３５編１２０条に基いて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約３６５条 (c) に基ずく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第３５編１１２条第１項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第３７編１条５６項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

私は、私自身の知識に基ずいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基ずく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典１８編第１００１条に基ずき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Japanese Language Declaration
(日本語宣言書)

委任状：　私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁護士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

Thomas E. Beall, Jr., Reg. No.22,410; John R. Mattingly, Reg. No.30,293; Daniel J. Stanger, Reg. No.32,846; Shrinath Malur, Reg. No.34,663; Gene W. Stockman, Reg. No.21,021; Jeffrey M. Ketchum, Reg. No.31,174; and Scott W. Brickner, Reg. No.34,553.

書類送付先

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MATTINGLY, STANGER & MALUR, P.C.
1800 Diagonal Road, Suite 370
Alexandria, Virginia 22314

直接電話連絡先：(氏名及び電話番号)

Direct Telephone Calls to: *(name and telephone number)*
Telephone: (703) 684-1120
Fax (703) 684-1157

唯一または第一発明者		1-0 Full name of sole or first inventor Hiroshi INOUE
発明者の署名	日付	Inventor's signature: Hiroshi Inoue　Date: 03/28/2002
住所		Residence Hitachinaka, Japan JPX
国籍		Citizenship Japan
私書箱		Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan

(第二以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for second and subsequent joint inventors.)

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第二共同発明者	2-0 Full name of second joint inventor, if any Tomomi KOGANEZAWA
第二共同発明者の署名　　日付	Second inventor's signature　　Date Tomomi Koganezawa　　03/29/2002
住所	Residence Hitachi, Japan SPX
国籍	Citizenship Japan
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第三共同発明者	3-0 Full name of third joint inventor, if any Nariyoshi KOBAYASHI
第三共同発明者の署名　　日付	Third inventor's signature　　Date Nariyoshi Kobayashi　　03/29/2002
住所	Residence Hitachinaka, Japan SPX
国籍	Citizenship Japan
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第四共同発明者	4-0 Full name of fourth joint inventor, if any Masaya OHTSUKA
第四共同発明者の署名　　日付	Fourth inventor's signature　　Date Masaya Ohtsuka　　04/01/2002
住所	Residence Mito, Japan SPX
国籍	Citizenship Japan
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第五共同発明者	5-0 Full name of fifth joint inventor, if any Kazuyuki ITO
第五共同発明者の署名　　日付	Fifth inventor's signature　　Date Kazuyuki Ito　　04/05/2002
住所	Residence Hitachinaka, Japan SPX
国籍	Citizenship Japan
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan

(第六以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for sixth and subsequent joint inventors.)

10088119 .071802

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第六共同発明者	6-00 Full name of sixth joint inventor, if any Isao TAKEHARA
第六共同発明者の署名　日付	Sixth inventor's signature　Date Isao Takehara　03/28/2002
住所	Residence Hitachi, Japan
国籍	Citizenship Japan
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第七共同発明者	Full name of seventh joint inventor, if any
第七共同発明者の署名　日付	Seventh inventor's signature　Date
住所	Residence
国籍	Citizenship
私書箱	Post Office Address
第八共同発明者	Full name of eighth joint inventor, if any
第八共同発明者の署名　日付	Eighth inventor's signature　Date
住所	Residence
国籍	Citizenship
私書箱	Post Office Address
第九共同発明者	Full name of ninth joint inventor, if any
第九共同発明者の署名　日付	Ninth inventor's signature　Date
住所	Residence
国籍	Citizenship
私書箱	Post Office Address

(第十以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for tenth and subsequent joint inventors.)